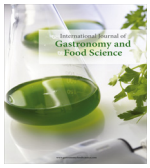

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Scientific Paper

Consumer perception of food–beverage pairings: The influence of unity in variety and balance

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Abstract

Good pairing recommendations may be crucial for the success of foods and beverages, both in the retail and hospitality sector. Food–beverage pairings are often presented by culinary professionals such as chefs or sommeliers, however little focus has been given to consumer perception of such pairings. The main objective of this study was to investigate consumer perception of overall percepts of food–beverage pairings. Combinations of soup and craft beer were used as model pairings. Soups were developed by a chef according to an experimental design with the basic tastes as factors. Craft beer types were selected according to sensory profile, popularity in the market and culinary recommendations. Results from the consumer study demonstrated significant effects of beer type on liking. Relative-to-ideal ratings for balance demonstrated that dominance of either of the components significantly reduced liking and harmony, while dominance of soup significantly reduced perceived complexity. Results also demonstrated that perceived sensory complexity was highly correlated with liking of pairings when perceived sensory harmony also was rated as high. This study introduces the use of a "just about balanced" (JAB) scale for rating the relative balance of intensity between two products. Some of the challenges with combining culinary creativity with experimental product development are also discussed.

Keywords: Consumer; Sensory; Culinary; Pairings; Complexity

Introduction

Good pairing recommendations may be crucial for the success of foods and beverages, both in the retail and hospitality sector. Due to the complex nature of the sensory interactions between food and beverages it is difficult to determine universal guidelines for creating good pairings. Systematic studies of the overall perception of food–beverages pairings may contribute to explain why certain pairings are perceived as more sensory appealing than other. In this study, craft beer was used as the model beverage. While wine and food pairings is an established concept, the relationship between beer and food is less defined, more depending on the occasion (Pettigrew and Charters, 2006). Popularity of craft beer has been growing among young consumers in general and female consumers in particular the last five years (Brewery Business 2012, http://www.sbdcnet.org). Consumers born after 1980, often referred to as Millenials, are reported to be the largest consumer segment for craft beer (Pew Research Center, 2010; The Nielsen Company, 2014). Guides and online resources, such as the "Beer Sommelier" developed by beer experts such as beer judge Eric McKay, Brooklyn Brewery brewmaster Garrett Oliver and beer writer Michael Jackson, offers automated beer suggestions based on selection of main ingredient and dish type (Great Brewers, 2014). While this provides a quick and user-friendly service for consumers and

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food service professionals, it offers no systematic explanations for the suitability of the suggested pairings. In addition, such guides provides limited information regarding pairings with novel dishes and ingredients.

There is an abundance of theories in culinary literature for pairing food and beverages however most approaches are subjective in nature and difficult to test objectively. A review of relevant books on the subject (see Appendix A) showed that balance of flavor intensity was among the most frequently cited principles regarding successful pairings. In addition, the importance of sweet–sour balance between the products was frequently cited. While most pairing theories have been developed with wine in focus they should also be relevant for beer as the products has many of the same sensory dimensions. Integrated terms such as "harmony" and "complexity" are often used to describe the overall perception of food pairings in culinary literature, related to how well the tastes and flavors go together and the sensory variation in the pairing. Such terms can be viewed in relationship with the arousal potential of the pairings. Berlyne (Levy et al., 2006) described a group of collative properties which influence the arousal potential of objects, such as e.g. novelty, familiarity and perceived complexity. According to his arousal theory there is an inverted U-shaped relationship between perceived complexity and liking; everyone have an individual optimum level of complexity and if the perceived complexity is too low or too high, the liking is reduced. Harmony and complexity can also be related to the more general concept of "unity in variety" which states that people prefer objects with a high variety or complexity while the object maintains a maximum of perceived unity or harmony (Hekkert and Leder, 2008).

There have been relatively few published studies on food–beverage pairings and most of these studies have focused on wine as the beverage for the pairings. Nygren et al. (2001, 2002, 2003a, 2003b), investigated sensory interactions between white wine and food components such as sauce and cheese using trained panelists, while Madrigal-Galan and Heymann (2006) investigated the sensory interactions between red wine and cheese. The results from these studies demonstrated that the food components generally had a bigger impact on the sensory profile of the wine, than vice versa. King and Cliff (2005), investigated the ideal pairing of wine and cheese assessed by culinary professionals. While they found that white wine in general scored closer to ideal pairing with the cheeses compared to red and specialty wines, they also observed large individual differences between the experts. Harrington and Hammond (2005, 2006) investigated the impact of specific sensory properties of cheese, wine and additional food elements on perceived match between cheese and wine pairings using trained panelists and wine experts. In addition, Harrington et al. (2010) explored the impact of flavor and body match on overall match perception. Results from these studies demonstrated some significant effects related to specific sensory properties on match perception. Also, large individual differences among panelists regarding perceived match perceptions were observed. Koones et al. (2014) explored the impact of sweetness, acidity and tannin levels in wines and the level of wine expertise among consumers, on the level of perceived match between wine and different foods. In addition to significant effects related to the investigated properties on match perception, results demonstrated that the level of knowledge influenced general match perception. Bastian et al. (2009) investigated match perceptions between consumers and experts of ideal wine and cheese pairings. They found a high consensus between the consumers and the experts regarding mathing of pairings, which indicated that the underlying principles used by the culinary professionals for selecting the pairings were valid. Bastian et al. (2010) investigated both the sensory interactions and match perception among consumers of food and wine pairings. Significant sensory interactions between the pairings could be determined, however results from the consumer ratings revealed that match perception were mainly related to the overall preference for the wine. In addition to the studies focusing on wine, some studies have also investigated the use of beer in food–beverage pairings. Donadini et al. (2008) compared how culinary experts and regular consumers perceived suitability of pairings of popular Italian dishes and conventional beers. Differences between experts and consumers regarding in the perceived suitability of the pairings were observed even though pairings generally were rated as poor. Harrington et al. (2008) investigated match perception between beer types such as lager, ale and stout, with spicy and non-spicy pizza among novice and experienced beer drinkers. Results from this study indicated that the choice of beer with non-spicy pizza was mainly related to beer preference, while beer with more flavor and fuller body tended to be selected with spicy pizza.

Food and beverage pairings are complex stimuli which can be challenging to rate in a consistent manner both by experts and naïve consumers. Previous pairing studies have demonstrated both agreement and disagreement between consumers and experts, and between the experts themselves, regarding match perception of food and beverage pairings (Bastian et al., 2009, Donadini et al., 2008; King and Cliff, 2005; Koones et al., 2014). Chollet and Valentin (2001) found that while experts were better than untrained consumers to use precise terms to describe beer, their performances were similar regarding a matching task. This suggests that untrained subjects may provide equally accurate information regarding general aspects such as overall perceptions of product quality as experts or trained subjects. Different scales have also been applied for the assessment of match perception of food and beverage pairings in these studies. Some studies have applied Likert scales with various ranges for rating overall food and beverage match, ranging from no match in one end of the scale to ideal match in the other end (Donadini et al., 2008; Harrington and Hammond, 2005; Koones et al., 2014) while other studies have used JAR scales to explore various deviation-from-ideal ratings of the match between the food and the beverage (Bastian et al., 2009, 2010; Harrington and Hammond, 2006; Harrington et al., 2008, 2010; King and Cliff, 2005).

The main aim of this study is to investigate consumer perception of overall percepts of food and beverage pairings, using craft beer as the beverage. Measured responses were liking, using 9 point hedonic scales, and perceived sensory

harmony, complexity and balance of pairings, using modified JAR scales. The results and suggested approaches from this study are relevant for the food industry and culinary professionals for developing food–beverage pairings.

Materials and methods

Soup and beer pairings

In this study, pairings of soup and craft beer were used as samples. Craft beer was used as the beverage item because it is a popular beverage commonly paired with food. Craft beer also has a large variation in the sensory profile which is ideal for creating pairings with significant sensory differences. Soup was used as the food item because it represents a food matrix which is relatively easy to manipulate in terms of sensory dimensions. It was decided to use a soup based on potato, leek and chicken stock because it has a mild, balanced taste. It is also a relatively neutral food in terms of pairing recommendations, with no specific beer pairing tradition.

Soups

Basic tastes were the experimental factors in the design of the soups, using the approach of Creative Design (Næs and Nyvold, 2004). Only samples with main effects were used. All basic taste soups were developed for another study focusing on the sensory interactions between soup and beer using Descriptive Analysis (DA) (results not included in this paper). The criteria were that the basic taste should only be increased for sample with high level of the corresponding factor, and that all the soups should have an equal appearance and mouth-feel. The soups were developed by a chef according to the experimental design in Table 1, using culinary ingredients to represent both high and low level of the factors. During the development phase the soups were analyzed with DA.

For the reference soup the ingredients were: 22.5 g shallot onion, 75 g leek, 19.5 g unsalted butter, 6 dl water, 1.5 cube chicken stock (Maggi), 300 g mealy potatoes (Kerrs Pink), 0.15 g dried thyme, 1.5 g fresh lemon juice, 1.5 g of fresh grapefruit juice, 0.075 g finely grounded pepper. The finished volume was 20 dl. The onion was blanched in butter before the leek was added and also blanched. Potato cut into 0.5 cm × 0.5 cm cubes were then added together with the chicken stock (1.5 cube dissolved in the water) and the spices. This mixture was left to boil for 15 min in order to cook the potatoes properly. After boiling, the mixture was pureed into a smooth soup using a hand blender. Lemon and grapefruit juice was added just before serving for all soups. The reference soup was used as a base soup for all the other soups. For the sweet soup, 2 g of honey and 4 g sugar was added to the reference mixture before blending. For the sour soup, 4 g fresh lemon juice and 4 g fresh orange juice was added to the finished reheated reference soup in order to prevent heat degradation of lemon and orange flavors. For the salt soup, 1.9 g sea salt (Maldon) was added to the reference mixture before blending. For the bitter soup, 60 g raw chicory (only the white part, coarsely chopped) and 2 g of fresh grape juice was added to the reference mixture before blending. For the umami soup, 0.30 g sodium glutamate was added to the reference mixture before blending.

The list of descriptors used for the soups is shown in Table 2. DA of the soups was conducted in three sessions with a total of 12 soup samples (six soups in replicate). In addition a dummy sample was served in the beginning of the test.

Table 1
Experimental design of soups.

Sample	Sweetness	Sourness	Saltiness	Bitterness	Umami
Reference soup	−	−	−	−	−
Sweet soup	+	−	−	−	−
Sour soup	−	+	−	−	−
Salt soup	−	−	+	−	−
Bitter soup	−	−	−	+	−
Umami soup	−	−	−	−	+

+ = high level, − = low level.

Table 2
Sensory attributes for DA of soup.

Attributes	Definitions
Tot. intensity (O)	Overall intensity of all odors
Herbs (O)	Herbal odors (parsley, thyme)
Vegetables (O)	Vegetable odors (leek, onion)
Tot. Intensity (F)	Overall intensity of all tastes and flavors
Sour (F)	Organic acids
Sweet (F)	Sucrose
Salt (F)	NaCl
Bitter (F)	Caffeine
Umami (F)	Umami
Herbs (F)	Herbal flavors (parsley, thyme)
Vegetables (F)	Vegetable flavors (leek, onion)
Fullness (T)	Perception of full rounded textural sensation in the mouth.
Smoothness (T)	Geometrical textural attribute related to the perception of the size and shape of particles in the product
Aftertaste	Perception of taste 15 s after expectoration of the product.

O = odor, F = flavor, T = texture.

A session consisted of three or four soup samples served every 5–7 min. All samples were served with three digit random codes and evaluated monadically at individual speed and registered continuously. The samples were served in the same randomized order for all assessors. DA of the soups was conducted a week before the DA of the soups and the sequential tasting. Due to practical restrictions regarding the preparation of the samples, all samples were served according to the same randomized order for all assessors, with all assessors assessing the same samples simultaneously. 0.5 dl soup was served in warm porcelain bowl with lids, heated in a hot closet (60 ± 1 °C). The bowls were placed on heated plates in the sensory booths (67 ± 2 °C) and served with plastic soup spoon. Serving temperature was 58 ± 2 °C for the soups. The assessors were instructed to taste a spoonful and rate all the attributes. All samples were expectorated and unsalted crackers and lukewarm water was available for rinsing.

Beer

All beers used in this test were commercially available products produced by Norwegian craft brewery Nøgne Ø (www.nogne-o.com). All products were unpasteurized and unfiltered. This brewery was chosen because it produces a wide range of beer styles and they were able to deliver beer representing the same batches. The selection of the beer samples were based on the following criteria:

- culinary recommendations
- popularity of beer style
- sensory profile

Hop-rich beers, such as IPA and APA, are among the most popular styles of craft beer. They are usually dominated by high bitterness and hoppy and malty aromas. Such beers are often described as all-round beers for pairing with foods, from spicy food to sushi. Wheat beer, like Saison and Wit, are often recommended for pairing with fish and lighter dishes such as soups as they are generally less bitter, have a slightly sour taste and fresh, fruity aromas (www.vinmonopolet.no, http://www.brewersassociation.org, http://www.ratebeer.com). Based on the brewer's recommendation about beer styles and the general culinary recommendations, a subset of their products was initially tested using DA on a trained panel. The tested beers were hops-dominated ales, such as India Pale Ale (IPA), American Pale Ale (APA) and Bitter, and wheat-based, ester-dominated ales, such as Tiger Tripel, Saison and Blond. Based on these results from the DA (not shown) it was determined to use APA to represent the hop-rich pairing. An additional DA was performed in order to identify a beer with significantly higher intensity of sourness, including a wheat-based Wit beer. During this process, wheat-based beers from other producers were also considered. Based on these combined results, APA and Wit were selected as the beer types for the food–beverage pairings (Table 3).

DA of the beers (two beers in triplicate) was conducted in two sessions with three samples. All samples were served with three digit random codes and monadically evaluated at individual speed and registered continuously. 0.5 dl beer was served in clear plastic glasses and all samples in a session were placed on top of ice-filled containers covered with serving trays in the sensory evaluation booths. Serving temperature was 9 ± 2 °C for the beer. Samples within each session were evaluated in individual randomized order by each assessor. All beers were from the same batch for the respective beer types. The assessors were instructed to take a sip of the beer and rate all the attributes. All samples were expectorated and unsalted crackers and warm and cold water was available for rinsing. Table 4 shows the list of sensory attributes for the beers.

Fig. 1 shows the results from the final sensory profiling of the two beer types used in this study: Wit and APA. Wit has significantly higher intensity of sourness, fruit flavor. APA has significantly higher total astringency, fullness, hops flavor, malt flavor, total flavor intensity, aftertaste and bitterness. No sensory differences are demonstrated for total odor intensity, sweetness, floral flavor and yeast flavor.

Table 3
Production information for beer samples included in the study.

Beer sample	Yeast type	Fermentation	Alcohol vol. (%)	IBU
Wit	Belgian beer yeast	Top fermented	4.5	20
APA	English ale yeast	Top fermented	6.0	40

Table 4
Sensory attributes for DA of beer.

Attributes	Definitions
Tot. intensity (O)	Overall intensity of all odors
Herbs (O)	Herbal odors (parsley, thyme)
Vegetables (O)	Vegetable odors (leek, onion)
Tot. intensity (f)	Overall intensity of all tastes and flavors
Sour (F)	Organic acids
Sweet (F)	Sucrose
Salt (F)	NaCl
Bitter (F)	Cafffeine
Umami (F)	Umami
Herbs (F)	Herbal flavors (parsley, thyme)
Vegetables (F)	Vegetable flavors (leek, onion)
Fullness (T)	Perception of full rounded textural sensation in the mouth
Smoothness (T)	Geometrical textural attribute related to the perception of the size and shape of particles in the product
Aftertaste	Perception of taste 15 s after expectoration of the product

O = odor, F = flavor, T = texture.

Sensory analysis

The samples used in this study were pairings of soup and beer. A total of six soups and two beers were profiled and in addition the effect of soups on beer was evaluated. The DA was conducted by a trained sensory panel at Nofima. All

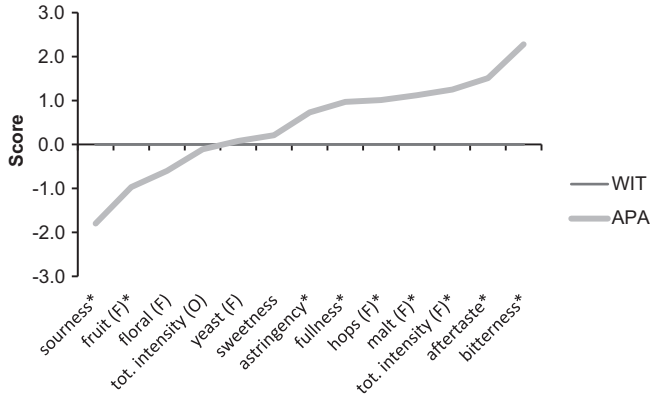

Fig. 1. Descriptive analysis of beer – sensory differences (* indicate significant differences according to ANOVA).

Table 5
Overview of soup–beer combination used in DA and consumer test.

Soup	Beer	DA	Consumer test
Reference	APA	x	x
Sweet	APA	x	x
Sour	APA	x	x
Salt	APA	x	
Bitter	APA	x	
Umami	APA	x	
Reference	Wit	x	x
Sweet	Wit	x	x
Sour	Wit	x	x
Salt	Wit	x	
Bitter	Wit	x	
Umami	Wit	x	

APA = American Pale Ale, Wit = Wit beer.

assessors were selected and trained in accordance with ISO 8586-1 (ISO, 1993) in a sensory laboratory designed in accordance with ISO 8589 (ISO, 2007). Each assessor evaluated all samples using EyeQuestion for direct recording of data (v3.8.7, Logic8, Holland).

The assessors were trained in the evaluating the soups in three two-hour sessions, the beer in six two-hour sessions and the soup–beer pairings in three two-hour sessions. Attributes were generated in separate brainstorming sessions for soup and beer respectively. The final list of attributes for beer was adjusted according to samples used in the final DA. Table 5 shows an overview over soup–beer pairings investigated for DA.

Consumer test

In order to avoid sensory fatigue, only six pairings was used for the consumer test. The sweet, sour and the reference soup were selected in order to investigate the influence of sweet-sour balance on the overall perception of the pairings. In addition, both beer types were included in order to investigate the potential effects on perception of balance of flavor intensity of pairings. Table 5 shows an overview over soup–beer pairings investigated for the consumer test.

Table 6
Overview over consumer demographics.

	Total	Female		Male	
	n	*n*	%	*n*	%
	80	39	48.8%	41	51.3 %
Mean age	23.1	22.5		23.8	
Min. age	20				
Max. age	29				

Subjects

Eighty subjects evaluated six beer–soup pairings in eight different sessions, with up to twelve subjects in each session. The subjects were recruited on the campus of the University of Life Sciences in Norway, according to the following criteria:

- Regular consumers of beer (min 2–3 times per month).
- Pairing beer with food on a regular basis (min 2–3 times per month).
- General knowledge about beer types and breweries.
- Age between 20 and 29.
- 50% male, 50% female.

Overview of consumer characteristics can be found in Table 6. Consumers drinking beer and pairing it with food more frequently than 2–3 times per month were defined as high frequency users, while the other subjects were defined as low frequency users in order to determine effect of frequency of use on perception of complexity and liking.

Responses

The subjects were asked to rate the liking of the individual products and the parings. In addition questions related to overall perception of pairings were included, related to harmony, complexity and balance.

- Liking beer; liking soup, liking pairing; (9-point, numerical category scale anchored with “dislike very much” and “like very much”).
- Complexity; defined as “How many sensations and aromas do you perceive in this pairing?” (9-point scale anchored with “Few” and “Many”).
- Harmony; defined as “How well does the different sensations and aromas in this pairing go together?” (9-point scale anchored with “Don't go together at all” and “Go very well together”).
- Balance; defined as “How do you perceive the balance of flavor and aroma intensity between beer and soup for this pairing?” (5-point “just about right” scale anchored with “Soup dominates too much” and “Beer dominates too much” and with “Just about balanced” in the middle).

The choice of responses were based on the results from the pre-study on the perceived complexity in fruit juices was

performed at Nofima (unpublished results) using a questionnaire developed for evaluating the perceived complexity in wine using pictures as anchors on line scales (Medel et al., 2009). The questionnaire consisted of eight item; familiarity, number of aromas, ease of identification or description, homogeneity, harmony, balance, persistence and power. In addition, consumers were asked to rate overall complexity. Results from this pre-test showed that overall complexity was positively correlated with the number of perceived aromas, persistence and intensity. There was also a strong correlation between harmony, homogeneity and balance, suggesting redundancy of items. Similar correlations were found in the study by Medel et al. (2009) and in an additional wine-study by Meillon et al. (2010). General feedback from the pre-test indicated that the consumers perceived many of the correlated items as overlapping and redundant. Feedback also indicated that the explicit use of terms such as harmony and complexity was confusing despite the use of picture anchors.

This study introduces the use of the "just about balanced" (JAB) scale, based on a "just about right" scale. This question was related to the relative-to-ideal perception of balance between two products, rather than the in-product balance as used in the questionnaire used by Medel et al. (2009).

Test procedures

The consumer test was carried out in the evaluation booths at the sensory laboratory at Nofima, with eight sessions over three consecutive days, with maximum twelve consumers in each group. The subjects evaluated six coded beer-soup pairings (blind test). In addition a dummy pairing was used as a warm-up sample. All samples were evaluated at individual speed and registered continuously using EyeQuestion v3.8.7 (Logic8, Holland).

Before the test started, water, dried fruits and nuts were available for consumption in the waiting area to reduce potential effects due to excessive hunger and thirst. All subjects had to sign on a consent form agreeing not to drive a vehicle immediately after the test before the test started. A short oral instruction about the test was presented to the group. The same information was also available in written form on the computer screens in the evaluation booths. The subjects evaluated six coded beer-soup pairings (blind test). In addition a dummy pairing was used as a warm-up sample. Each pairing was presented with a 3-digit random code corresponding with a code on a beer and a soup sample. Beer samples (0.5 dl) were put in trays filled with crushed ice and soup samples (0.5 dl) were put on electrical heating plates (67 ± 2 °C) in the sensory booths. Serving temperature was 9 ± 1 °C for the beer and 58 ± 2 °C for the soups. Based on feedback from DA of the beer and soup, beer temperature was increased to 9 °C instead of the recommended serving temperature of 8 °C in order to reduce the temperature contrast between the warm soup and the cold beer.

Subjects were instructed to take a sip of the beer and rate liking; then taste the soup and rate liking; and finally rate liking for the pairing of beer and soup. The subjects were then instructed to taste the pairing of soup and beer according to how they found natural for them. They were also asked to rate the perceived "complexity", "harmony" and "balance" for the given pairing. The subjects were instructed to rinse with water and biscuits before and after tasting the individual beer and soup samples. Due to practical limitations regarding the preparation of the samples, for each session all samples were served according to the same randomized order, with all subjects assessing the same beer-soup pairing simultaneously. Firstly, four pairings were served simultaneously. A break was introduced before the last three pairings were served, minimum 5 min or until everyone had finished evaluating the first four pairings.

At the end of the actual test, participants were asked questions about age, gender and beer habits; frequency of beer consumption, frequency of pairing beer with food, which beer-types they usually drink (according to beer type categories) and which type of beer they usually buy (according to production type).

Statistical analysis

Descriptive analysis

For each product (soup, beer) a General Linear Models (GLM) with main affects product and assessor, product–assessor interaction, with product nested in batch, was performed to determine which attributes significantly discriminated between samples. Beer and soup samples were nested in batch in the respective model. PanelCheck 1.3.2 (www.panelcheck.com) was used to evaluate the panel performance of the sensory panel. Tucker-1-plots were used to evaluate the consensus of sensory attributes among the panelists.

Consumer data

A two-way ANOVA model with subject (random) and product (fixed) as main effects was used to determine possible significant differences in liking between beer and soups, and liking, complexity and harmony for pairings. The interaction was confounded with the error term and was not estimable (Næs et al., 2010). Tukey's Multiple Comparisons Test using Minitab v16.1.1 (Minitab Inc., USA) was applied to discern which groups were significantly different.

In order to highlight any relationship between perceived complexity and liking according to level of perceived of harmony, Pearson correlation coefficients (r) were calculated using Minitab v16.1.1 (Minitab Inc., USA), based on mean scores for complexity and liking according to each level of harmony rated for pairings. Significance of coefficients was tested under the null hypothesis $r=0$ ($\alpha=5\%$).

Consumer responses related to relative-to-ideal perception of balance of pairings were analyzed according to penalty analysis in relation to mean drop in liking, complexity and harmony (Lawless and Heymann, 2010). Mean liking scores were analyzed with One-way ANOVA related to dominance of soup (below ideal), "just about balanced" (relative-to-ideal) and dominance of beer (above ideal).

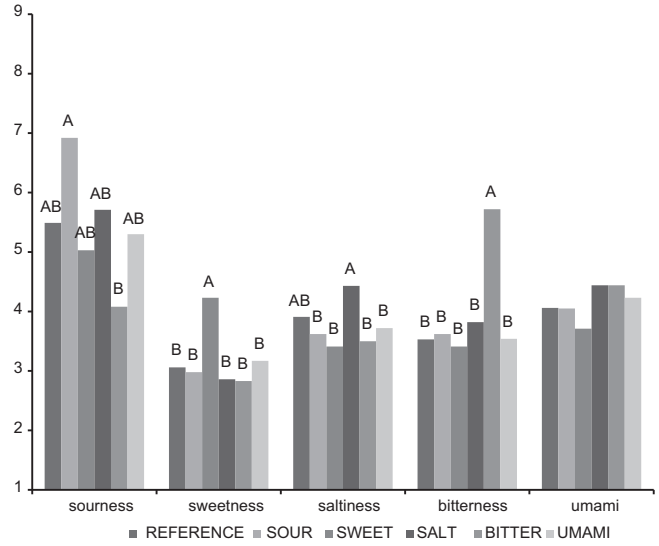

Fig. 2. Descriptive analysis of all soups (only basic tastes are shown). Different letters indicate significant differences according to Tukey's test.

Results

This section will present results for the DA of the soups, results from the sequential tasting of soup and beer and results from the consumer test.

DA soups

Results from DA of soups regarding the intensity of the basic tastes are presented in Fig. 2.

Fig. 2 shows that the sweet and bitter soup had significant higher intensity of the corresponding basic taste. The salty soup had significantly higher saltiness than other soups except the reference soup. The sour (acidic) soup had only significant higher sourness than the bitter soup. No significant differences were found between soups regarding umami taste. ANOVA results also demonstrated a significant difference for total flavor intensity (not shown), however no differences between samples were identified in the Tukey's test.

Consumer test

In this section, result from the consumer test is presented. Results regarding the liking of the individual beers and soup are presented in Fig. 3. Results regarding the liking, complexity and harmony are presented in Fig. 4. The relationship between mean complexity and mean harmony according to liking of pairings is presented in Fig. 5 and Table 7. Results from penalty analysis of relative-to-ideal ratings in relationship to mean liking is presented in Table 8.

Fig. 3 shows that there are significant differences regarding the liking of the beer. ANOVA results also demonstrated significant gender effects for liking of beer. The ranking was the same (results not shown). No significant differences are observed for mean liking for the soups.

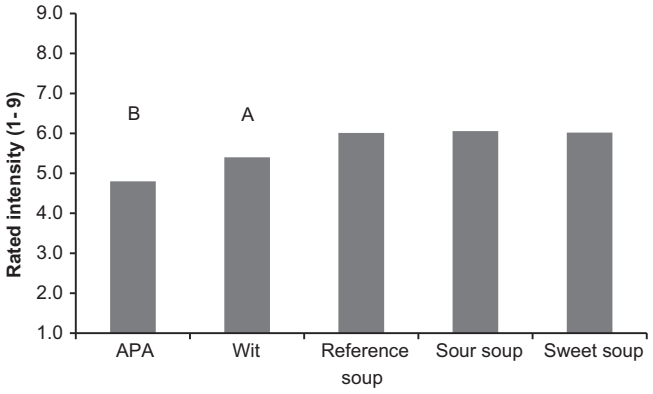

Fig. 3. Mean liking for beer and soup samples (means and standard deviations). (Different letters indicate significant differences according to ANOVA).

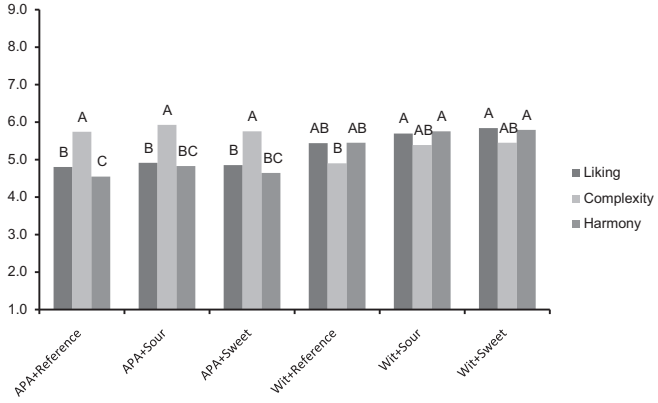

Fig. 4. Mean consumer responses for beer–soup pairings. (Different letters indicate significant differences according to Tukey's test).

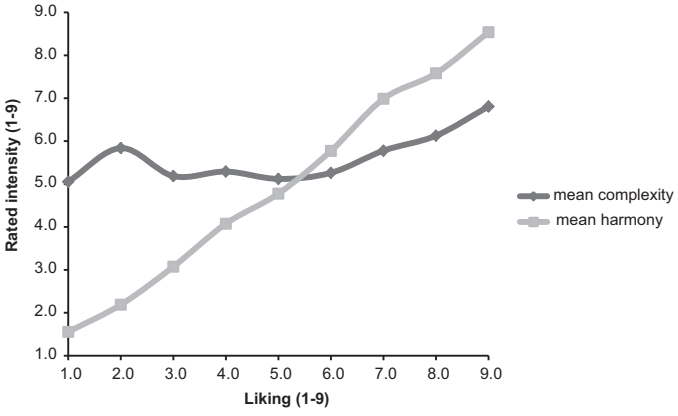

Fig. 5. Relationship between mean complexity and mean harmony according to liking of all soup–beer pairings.

Fig. 4 shows that there was a significant effect of beer type on the mean liking and the perceived harmony and complexity of the pairings. No significant effect was observed regarding soups. All pairings with APA had a significantly lower mean liking than Wit combined with sour soup and sweet soup. The pairing of APA and reference soup had significantly lower harmony compared to all pairings with Wit, while the pairing

Table 7
Correlations between mean complexity and mean liking according to rated harmony of combinations.

Rated harmony	Pearson correlation coefficient	*p*-Value
Overall (1–9)	0.735	0.024
High (5–9)	0.941	0.017
Low (1–5)	0.242	0.695

Table 8
Overview of penalty analysis of relative-to-ideal ratings related to mean drop in hedonic liking, complexity and harmony.

Pairing balance		**Liking**		**Complexity**		**Harmony**		**Total**	
		Mean	Change	Mean	Change	Mean	Change	*n*	%
Soup dominates	*APA*	*4.8*	*−1.9*	*4.1*	*−1.5*	*4.4*	*−2.3*	*16*	*3*
	Mean	**4,9b**[1]	**–**	**4,1b**[1]	**–**	**4,6b**[1]	**–**	**50**	**10**
	Wit	*4.9*	*−1.7*	*4.2*	*−1.4*	*4.7*	*−2.0*	*34*	*7*
Just-About-Balanced	*APA*	*6.8*	*0.2*	*6.1*	*0.5*	*6.8*	*0.0*	*58*	*12*
	Mean	**6,6a**[1]	**–**	**5,6a**[1]	**–**	**6,7a**[1]	**–**	**192**	**40**
	Wit	*6.5*	*−0.1*	*5.3*	*−0.2*	*6.7*	*0.0*	*134*	*28*
Beer dominates	*APA*	*4.2*	*−2.4*	*5.9*	*0.3*	*4.0*	*−2.7*	*166*	*35*
	Mean	**4,2b**[1]	**–**	**5,7a**[1]	**–**	**4,0b**[1]	**–**	**238**	**50**
	Wit	*4.3*	*−2.3*	*5.6*	*0.0*	*4.1*	*−2.6*	*72*	*15*
							Sum	**480**	**100**

Percentages within beer types are summed according total of the respective beer type.
[1] 1-way ANOVA.

with APA and sour soup and sweet soup had significantly lower harmony than pairings with Wit and sweet soup and sour soup. All pairings with APA had significantly higher complexity than the pairing with Wit and the reference soup. ANOVA results (not shown) demonstrated significant effect of gender on the liking of soup–beer pairings, however differences were not observed within specific pairings.

Fig. 5 shows that the best liked pairings were those which were perceived to have both high complexity and high harmony. Table 7 shows that complexity is highly correlated with liking for pairings with high harmony (rated harmony ≥ 5) and less correlated for pairings with low harmony (rated harmony ≤ 5).

Table 8 shows that both liking and harmony decreased significantly when either beer or soup dominated the pairing, while complexity only decreased significantly when the soup dominated. No significant differences were demonstrated for beer type. The table also shows that less than half of the rated pairings (40%) were perceived as "just about balanced" while 50% where perceived as dominated by beer and 10% were perceived as dominated by soup. No effects were demonstrated for soup type.

Discussion

The aim of this study was to investigate the overall consumer perception of soup–beer pairings, such as perceived sensory complexity, harmony and balance, in relation to the hedonic liking. In this section the general results from the study will be discussed, in addition to the limitations and practical implications of the study.

General discussion

Results related to perceived sensory complexity and harmony demonstrated that a high level of complexity was positively correlated with the liking of pairings when harmony also was perceived as high. This result is in accordance with the theory of unity in variety (Hekkert and Leder, 2008), which predicts that high sensory complexity, or variety, should be positively correlated with liking if sensory harmony, or unity, is perceived as high and less correlated if harmony is perceived as low. In previous studies on wine, harmony was found to be highly correlated with liking while there was a low correlation between overall complexity and liking (Meillon et al., 2010). Similar results were found in this current study when correlations in the raw data were investigated.

This study also introduced the use of JAB ratings for rating the relative balance in intensity between two components. Previous studies have asked subjects to rate various match perceptions of pairings as "just right" or "ideal" using modified JAR scales. (Bastian et al., 2009, 2010; Harrington and Hammond, 2006; Harrington et al., 2008, 2010; King and Cliff, 2005). The results regarding the balance ratings demonstrated for that liking and perceived sensory harmony was significantly reduced when either soup or beer was perceived to dominate the pairing, while perceived sensory complexity was significantly reduced only when soups dominated. Balance of the respective intensities of the components in pairings is often mentioned in the culinary literature as a fundamental for successful pairings (Harrington, 2005). These results demonstrated that balance, rated with JAB scales, was a good predictor of liking of pairings. The potential of the JAB scale should be further investigated in other applications related to combinations of sensory impressions.

The results also demonstrated large individual differences in the overall percepts of the pairings. Similar results have also been found in previous studies on wine and food pairings (Harrington and Hammond, 2005, 2006; Harrington et al., 2010; King and Cliff, 2005). In this current study all consumers were between the ages of 20 and 29 years old, so-called Millenials. This group of consumers is also generally regarded as being more diverse than previous generations (The Nielsen Company, 2014). These consumers are also the main market segment of craft beer, which makes them a highly relevant group for testing of the investigated pairings. However, no significant relationships could be established between the responses and the collected demographic data related to gender and consumption. This indicates that there are other underlying factors related to overall consumer perception of complex stimuli that needs to be identified. As individual optimum levels of complexity are likely to be more related with personal experiences and exposure to stimuli rather than age in itself, the results from this study can be generalized to other groups of consumers. Future studies should further emphasize the relationship between personal characteristics

and the overall perceptions of complex stimuli such as food and beverage pairings.

Limitations of study

While pairings with Wit were perceived as more balanced than pairings with APA, the pairings investigated in this study cannot be regarded as ideal food–beverage pairings in a traditional sense. According to Lawless and Heymann (2010), 80% just-about-right votes for the center category is a common benchmark for leaving the product as it is. Results from this present study shows that less than half all pairings were perceived as Just-About-Balanced. This indicates that the craft beers used in this test in general had too strong flavor intensity compared to the soups. Closer collaboration with culinary experts such as sommeliers could help to improve the selection of pairings in further studies. The results from the DA of the soups also demonstrated some of the challenges of combining experimental design and culinary considerations. From a culinary point of view, all the soups expressed variation in the basic tastes in a relevant and appropriate way, while from an experimental design point of view only the sweet and bitter soups were successful. While it would be relatively easy to develop soups with distinctive taste of sour or salty, such soups may not necessarily be perceived as appropriate by consumers.

Practical implications

The impact of the results in this study is relevant for beer brewers, food producers and culinary professionals. The applied approach for combining culinary knowledge and experimental design provides an efficient and flexible method for exploring and developing new food and beverage pairings, both in research and in food service settings. The use of the JAB scales for rating overall responses combined with penalty analysis represents a relatively simple tool for quick screening of potential pairings in a simple and efficient way. Regarding overall perceived complexity and harmony, results from this study suggests that the food industry and food service need to pay attention to such issues in order to develop new food and beverage pairings with a high impact in the market.

Conclusion

Results from this study provide new insights regarding overall perceptions of complex stimuli such as food and beverage pairings. The results demonstrated that perceived balance and the concept of “unity in variety” plays important roles in the consumer perception of pairings. Future studies should emphasize consumer characteristics that can describe the relationship between perceived sensory complexity, harmony and liking. The use of the JAB scale should be further investigated in order to evaluate the robustness of the measurement. The methodology and approaches applied for the development and testing of pairings are useful for the food industry and food service professionals.

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Appendix A

See Table A1.

Consulted books are listed below:

- Robinson, J., 2006. The Oxford Companion to Wine, 3rd ed. Oxford University Press.
- Robinson, J., 2003. Jancis Robinson's Wine Course, 3rd ed. Abbeville Press.
- Robinson, J., 2008. How to Taste – A Guide to Enjoying Wine, rev. ed. Simon & Schuster.
- Harrington, R.J., 2008. Food and Wine Pairing – A Sensory Experience. John Wiley and Sons.
- Dornenburg, A., Page, K., 2006. What to Drink With What You Eat. Bulfinch Press.
- Zraly, K., 2009. Windows to the World Complete Wine Course, 25th anniversary ed. Sterling Publishing Co.
- Goldstein, E., 2006. Perfect Pairings – A Master Sommelier's Practical Advice for Partnering Wine and Food. University of California Press.
- Goldstein, E., 2010. Daring Pairings – A Master Sommelier Matches Distinctive Wines With Recipes From his Favorite Chefs. University of California Press.
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- Casamayor, P., 2000. L'école des alliances – Les vins et les mets. Hacette Livre.
- Bernardo, E., 2011. Savoir marier le vin. Plon.
- Gastronomisk Institutt, 1997. Mat og vin i utsøkt harmoni. Gyldendal.

Table A1
Overview of the most common pairing principles cited in consulted culinary literature.

	Pairing principle	Quotes
1	Food sweetness level should be less than or equal to wine sweetness level	9
2	Wine overall body should be equal to food overall body	8
3	Wine and food flavor intensity should be equal	8
4	Food and wine flavor types can be matched using similarity or contrast	7
5	Fatty food requires a wine that cuts through the fat (either acidic, fruity or tannic)	7
6	Food acidity level should be less than or equal to wine acidity level	6
7	Wine tannin levels should be equal to animal-based food fattiness levels	5
8	Flavor persistency of wine and food should be equal	5

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